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COMPLETE SPECIFICATION

Improvements in Fuel Injection Devices for Multi-Cylinder Internal Combustion Engines

I, PIERRE ETIENNE BESSIERE, Citizen of the Republic of France, of 15, Rue Freycinet, Paris (Seine), France, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to multi-cylinder internal-combustion engine fuel injection devices in which a single fuel pump cylinder is connected, through a plurality of respective individual conduits, with a plurality of injectors each of which includes an injection valve arranged to open the injection orifice thereof under the effect of the pressure of the fuel to be injected and against the action of a closing spring.

The object of the present invention is to provide a fuel injection device of this kind which is better adapted to meet the requirements of practice than those known at the present time.

According to this invention, there is provided a multi-cylinder internal combustion engine fuel injection device in which a single fuel pump cylinder is connected, through a plurality of respective individual conduits, to a plurality of injectors each of which includes an injection valve arranged to open an injection orifice thereof under the effect of the pressure of the fuel to be injected acting thereon against the action of a closing spring, wherein each of the said conduits is controlled by a second valve which, during the intervals in which no injection takes place through the corresponding injector, is arranged to be held in a closing position by an energised electromagnet and which is arranged to be held in an opening position by the pressure of the fuel delivered from the pump when the electromagnet is brought out of action by control means acting upon the energising circuit of the said electromagnet.

Each of the said second valves is conveniently included in a valve construction, each of which valve constructions may include a body provided with a cylindrical recess communicating at one end with one of said individual conduits which is controlled by said second valve and a plunger slidable in said recess and rigid with the armature of the corresponding electromagnet, the fuel passage of that one of said injectors which is fed through said last mentioned conduit opening into the cylindrical wall of said recess, said passage being closed by said plunger when said electromagnet is energized.

Advantageously the said second valve body may be integral with the body of the corresponding injector.

The device may conveniently include a by-pass valve for the by-passing of fuel from the outlet of the pump, the by-pass valve being located in the outlet from the pump and upstream of the region where the individual conduits branch off, and electromagnetic means for controlling the opening of the by-pass valve. The device may also include a chamber in direct communication with the outlet from the pump, the individual conduits branching off from the chamber, the chamber being provided with an outlet orifice and the by-pass valve being mounted in the wall of the chamber to control the orifice.

The device according to this invention is adapted for use with an internal combustion engine which includes at least two cylinders, the cycles of which have a phase difference between them, the cylinders being fed with fuel from a single fuel feed pump cylinder, and is suitable for use with two or four-stroke Diesel or spark plug ignition engines.

In order that the invention may more readily be understood, one embodiment thereof will now be described with reference to the accompanying drawings, in which:—

Figure 1 is an elevational view, partly in section, of an embodiment of a fuel injection device according to this invention suitable

[*Price 3s. 6d.*]

for use with a four cylinder engine;

Figures 2 and 3 illustrate electro-mechanical means for controlling the electromagnetic locking means of the device of Figure 1.

On the appended drawings, this invention is supposed to be applied to a four cylinder four-stroke Diesel engine equipped with a single cylinder injection pump.

This pump includes a frame 1 in which is journalled the pump driving shaft 2. A cam 3 fixed on said shaft acts through a push-piece 4 upon the pump piston 5, which reciprocates in the pump cylinder 6. This cylinder is provided with fuel inlet ports 7 through which fuel enters cylinder 6 when piston 5 is in its lowermost position, as shown by Figure 1. Furthermore pump cylinder 6 is provided with a discharge valve 8 past which fuel is forced into delivery conduit 9 by piston 5 after the latter, during its upward movement, has closed the inlet ports 7. Delivery conduit 9 opens into a chamber 10 from which branch off four individual conduits 11*a*, 11*b*, 11*c*, 11*d*, each of which leads to an injector 12 corresponding to and mounted on one of the four cylinders of the engine.

Since the engine considered is a four-stroke engine, fuel injections into the engine cylinders follow one another at intervals corresponding to a rotation of 180° of the engine shaft. If the shaft 2 of the pump 1 is driven at a speed equal to one half of that of the engine shaft, the successive positions of shaft 2 for which the pump is delivering fuel are at 90° to one another. Therefore cam 3 includes four sectors so as to achieve four delivery strokes of pump cylinder 5 on every revolution of shaft 2.

Of course, on every fuel delivery by pump 1, only one of the four injectors 12 connected with this pump is to work, the three other injectors being then non-operative.

Several distributing devices for this purpose have already been suggested. But, as a rule, these known devices are complicated, expensive and not fully reliable in operation.

These drawbacks are eliminated with the device according to my invention. In this device, the communication between the conduit 13 which, in each injector 12, leads to the injection valve (not visible on the drawing) and the corresponding individual feed conduit 11*a* (or 11*b*, or 11*c*, or 11*d*) is controlled by valve constructions comprising a valve 14 held in closing position by electromagnetic locking means as long as the injector 12 is not to operate. Valve 14 is mounted in such manner that the fuel pressure in the feed conduit (for instance 11*a*) tends to open it so that fuel can pass freely into conduit 13 as soon as the electromagnetic locking means are brought out of action.

Valve 14 and its electromagnetic locking means may be mounted in a lateral projection 15, made of a magnetic material, of the body of injector 12.

Advantageously, as shown by the drawing, the electromagnetic locking means include a coil 16 housed in a circular groove provided in part 15 so that the combination of said coil 16 with the magnetic walls which surround it constitutes a circular electromagnet surrounding a cylindrical recess in which is slidably mounted a plunger 14. A disc-shaped armature 17, made of a magnetic material is rigid with said plunger 14. Advantageously, the disc constituted by armature 17 is provided with holes (not shown) extending throughout it so as to reduce its aerodynamic resistance to movement. A return spring 18 urges said armature 17 toward coil 16 during the suction stroke of the fuel pump piston.

Plunger 14, slidable in cylindrical recess 19, which is in communication with conduit 11*a*, controls the opening of a passage branching off from said recess 19 and forming the end of conduit 13 which leads to the injection valve. This arrangement makes it possible to avoid any air gap in the electromagnetic locking means without risk of the fuel-tightness of the valve being impaired by normal wear and tear. The same result may be obtained in the case of a needle valve by providing between said valve and the armature of the electromagnetic locking means a connection including any known means for automatically taking up the play.

As long as a current of sufficient intensity is flowing through coil 16, the fuel pressure transmitted through conduit 11*a* which is acting upon the end of plunger 14 is insufficient to overcome the locking action exerted by electro-magnet 16 upon armature 17. Plunger 14 cuts off the communication between recess 19 and conduit 13. On the other hand, when the current flowing through coil 16 is insufficient or is cut off altogether, the fuel under pressure in cylinder 19 lifts plunger 14 and flows to the injection valve which is spring loaded and opened by the fuel pressure, so that fuel is injected into the engine cylinder by the injector.

An electric control member, for instance in the form of a rotary switch 20 (Figure 2) controls the operation of the electromagnetic locking means, each of said means in succession being temporarily brought out of action for the period during which injection is to take place into the corresponding engine cylinder.

This control member may cut off, during a suitable time period, the energizing current which is normally flowing through the coils of the locking means (these coils being designated on Figure 2 by the reference numerals 16*a*, 16*b*, 16*c*, 16*d*). Instead of cutting off the energizing current, it may be sufficient

to reduce it sufficiently by inserting a resistance in the circuit thereof. I may also, according to a modification, provide a demagnetizing winding which is fed with current during the period for which the locking means are to be brought out of action.

In the embodiment illustrated by Figure 2, the rotating switch cuts off the energizing circuits of the respective injector locking coils successively. This switch therefore includes four conductive areas 21*a*, 21*b*, 21*c*, 21*d* along which are slidably mounted brushes inserted in the respective individual circuits of coils 16*a*, 16*b*, 16*c* and 16*d*. These circuits are connected in shunt fashion with one of the terminals of a current source 22, the other terminal of which is connected through a brush 23 with the four conductive areas 21*a*, 21*b*, 21*c*, 21*d*. Each conductive area is provided with a non-conductive gap and said non-conductive gaps are off-set along the rotary switch 20 so as to obtain the desired time offsetting between the fuel injection periods of the respective engine cylinders. Switch 20 is for instance mounted, as shown, on shaft 2.

Of course, instead of such a switch, I might use cam-operated electric contacts or the like.

The operation of the above described fuel injection device is as follows:—

During one complete revolution of shaft 2, which corresponds to two revolutions of the engine shaft, four successive delivery strokes of injection pump 1—8 take place. During each of these delivery strokes the valve 14 of one of the four injectors 12 successively is released so that, every time, injection takes place in a different engine cylinder. As soon as the fuel pressure on the end of plunger 14 ceases to exist (which is due either to the end of the delivery stroke or to the opening of an outlet port in the delivery circuit) return spring 18 closes the corresponding valve 14. At the same time the armature 17 of the electromagnetic locking means is returned on to the corresponding electromagnet 16, where it remains applied due to the fact that the energizing current is once more flowing through the corresponding coil.

In order to vary the injection timing, I may, in the usual fashion, vary the angular position of shaft 2 with respect to the engine shaft, which modifies both the angular position of cam 3 and that of switch 20.

Adjustment of the amount of fuel fed to every engine cylinder on every operation of the injector thereof may be obtained through any suitable means, for instance by the use of a by-pass valve controlling a leak or bleed orifice provided in the fuel feed pipe leading to the injector.

According to a particularly advantageous embodiment illustrated in Figure 1 of the drawings, such a by-pass valve, shown at 24 is provided in the delivery circuit of the pump upstream of the point where conduit 8 branches off to form individual conduits 11*a*, 11*b*, 11*c*, 11*d* leading to the respective injectors. In the embodiment illustrated by the drawing, this valve is therefore mounted in the wall of chamber 10.

Valve 24 is kept applied upon its seat by an electromagnet including a winding 25 housed in a recess of a support of magnetic material 26, so as to constitute two concentric annular poles 27 and 28 which co-operate with an armature 29 urged in the downward direction both by the pulling action of electromagnet 25—26 and by the resilient action of a return spring 30. As long as an energizing current of sufficient intensity is flowing through winding 25, valve 24 closes the leak orifice 31 provided in the wall of chamber 10. As soon as the current flowing through winding 25 is reduced or cut off, valve 24 opens and causes fuel to flow out through said orifice 31 and a second orifice 32 located downstream of valve 24, which immediately stops injection due to the sudden drop of pressure through conduits 9, 10, 11, so that valve 14 can close.

The fuel flowing out through orifice 32 is returned to the fuel tank or to the suction conduit of pump 1—8 through a passage which is not shown.

The energizing current of winding 25 may be controlled through any suitable means. However, advantageously, I make use of a rotating switch (Figure 3) constituted by a stationary brush 33 in contact with a cylinder rotated by the engine. This cylinder has its surface 34 constituted by a conductive material capable of co-operating with brush 33 so as to close the circuit of winding 25. In this conducting surface 34 are provided as many insulating strips 35 as there are separate fuel injections for one revolution of the rotating cylinder. In the case shown by the drawing, where said cylinder is driven by shaft 2, which also drives cam 3, the number of these strips is four. Each strip 35 has parallel edges oblique with respect to the generatrices of the cylinder. These insulating strips are disposed, with respect to the insulating areas of the strips 21*a*, 21*b*, 21*c* and 21*d* of switch 20 (Figure 2) in such manner that current is cut off in winding 25 generally after it is cut off in each of the coils 16*a*, 16*b*, 16*c* and 16*d* of the injectors and after the beginning of the delivery stroke of the pump. The exact time at which the energizing current is cut off in winding 25, and consequently the amount of fuel injected by each of the injectors, may be modified by displacement either of the cylinder on shaft 2 with respect to brush 33 (as shown in dotted lines on Figure 3) or of brush 33 parallel to the axis of shaft 2 and with respect to the

cylinder, which then remains stationary on shaft 2. This displacement may be effected either automatically, for instance by means of a conventional speed regulation system, or by direct control of the driver, for instance by means of a lever or pedal.

The respective valves 14, instead of being mounted on the corresponding injectors, may alternatively be grouped on the wall of chamber 10 so as to control the communication between said chamber and the respective conduits 11*a*, 11*b*, 11*c*, 11*d*, which would then lead directly to the corresponding injection valves.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of my invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the scope of the invention as set out in the accompanying claims.

WHAT I CLAIM IS:—

1. A multi-cylinder internal combustion engine fuel injection device in which a single fuel pump cylinder is connected, through a plurality of respective individual conduits, to a plurality of injectors each of which includes an injection valve arranged to open an injection orifice thereof under the effect of the pressure of the fuel to be injected acting thereon against the action of a closing spring, wherein each of the said conduits is controlled by a second valve which, during the intervals in which no injection takes place through the corresponding injector, is arranged to be held in a closing position by an energized electromagnet and which is arranged to be held in an opening position by the pressure of the fuel delivered from the pump when the electromagnet is brought out of action by control means acting upon the energizing circuit of the said electromagnet.

2. A device according to Claim 1 in which each of said second valve constructions includes a body provided with a cylindrical recess communicating at one end with one of said individual conduits which is controlled by said second valve and a plunger slidable in said recess and rigid with the armature of the corresponding electromagnet, the fuel passage of that one of said injectors which is fed through said last mentioned conduit opening into the cylindrical wall of said recess, said passage being closed by said plunger when said electromagnet is energized.

3. A device according to Claim 2 in which said second valve body is integral with the body of the corresponding injector.

4. A device according to any one of the preceding claims, including a by-pass valve for the by-passing of fuel from the outlet pipe of said pump, the by-pass valve being located in the outlet pipe of said pump upstream of the region where said individual conduits branch off therefrom, and electromagnetic means for controlling the opening of said by pass valve.

5. A device according to Claim 4, including a chamber in direct communication with the outlet pipe of said pump, said individual conduits branching off from said chamber, said chamber being provided with an outlet orifice and said by-pass valve being mounted in the wall of said chamber to control said orifice.

6. A fuel injection device substantially as hereinabove described and illustrated with reference to and as shown in the accompanying drawings.

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818,197 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

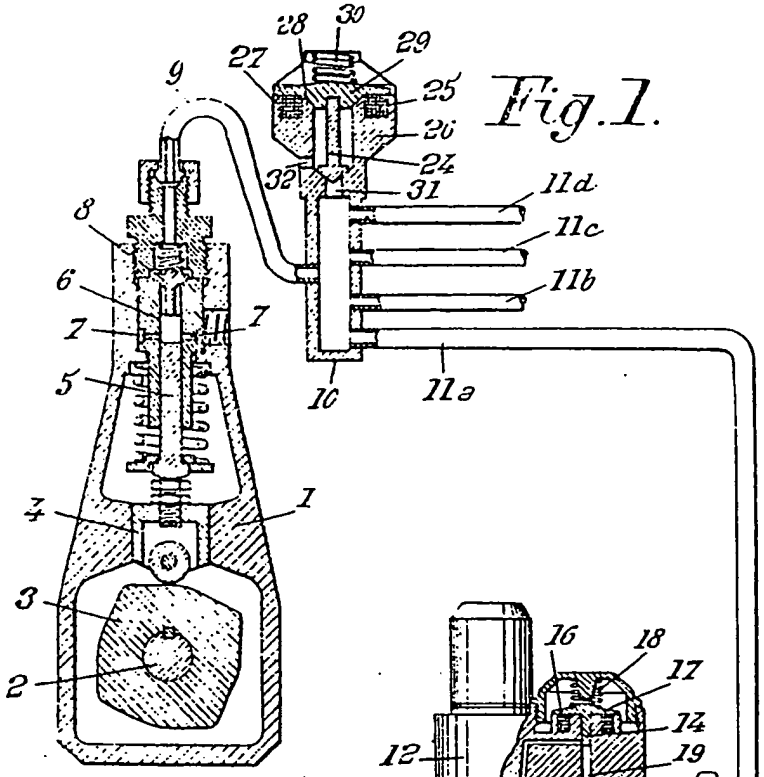

Fig. 1.

Fig. 2.

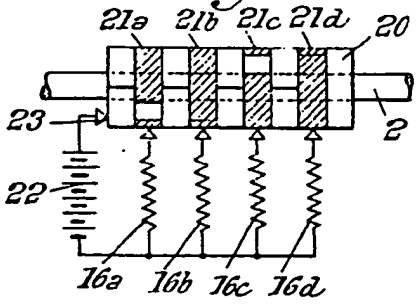

Fig. 3.